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Applicant: **TORAY INDUSTRIES, INC.**
 2, Nihonbashi-Muromachi 2-chome Chuo-ku
 Tokyo 103(JP)

Inventor: **Saito, Koichi**
 550-46, Yabase-cho
 Kusatsu-shi Shiga-ken(JP)

Inventor: **Kojima, Tatsuji**
 57-15, Gokasho Hirano
 Uji-shi Kyoto-fu(JP)

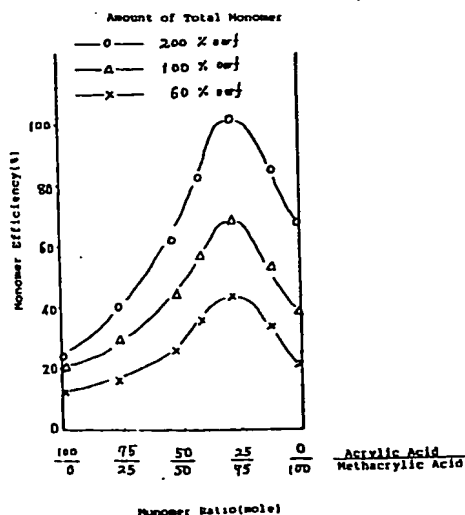
Inventor: **Kosaka, Yoshikazu**
 13-16, 1-chome, Ohira
 Otsu-shi Shiga-ken(JP)

Representative: **Weber, Dieter, Dr. et al,**
 Patentanwälte Dr. Dieter Weber und Klaus Seiffert
 Gustav-Freytag-Strasse 25
 D-6200 Wiesbaden 1(DE)

Method of modifying a synthetic or natural polyamide product.

A graft polymerisation is carried out in an aqueous solution containing 5 to 60 mole % of acrylic acid and 95 to 40 mole % of methacrylic acid as the monomer or by adding said aqueous solution to the polymerization system.

Fig. 1



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Dr. Dieter Weber
Klaus Seiffert

Patentanwälte

Dipl.-Chem. Dr. Dieter Weber · Dipl.-Phys. Klaus Seiffert
Postfach 6148 · 6200 Wiesbaden

D - 6200 Wiesbaden 1

Gustav-Freytag-Straße 23
Telefon 061 21 / 87 27 20
Telegrammadresse: Willpatent
Telex: 4-186247

Postcheck: Frankfurt/Main 87 63-802
Bank: Dresdner Bank AG, Wiesbaden,
Konto-Nr. 276807 (BLZ 51080060)

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Toray Industries, Inc.,
2, Nihonbashi-Muromachi, 2-chome,
Chu-Ku, Tokyo, 103 Japan

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Method of Modifying a Synthetic or
Natural Polyamide Product

15 Background of the Invention

This invention relates to a method of modifying a synthetic or natural polyamide products by means of a graft polymerization treatment.

20

Although various attempts have been made to modify syn-

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1thetic or natural polyamide-type products by graft polymerization, few methods are industrially feasible and capable of utilizing a graft monomer efficiently. A method of graft-polymerizing an acidic vinyl monomer to a polyamide-type product is described in various references such as Japanese Patent Publication No. 8543/1958, No. 7248/1959, No. 9283/1959, and No. 7834/1960. However, although these methods make it possible to graft the monomer on a laboratory scale, they call for radioactive irradiation or are disadvantageous in that the efficiency of utilization of the monomer (hereinafter called the "grafting efficiency") is as low as 30 % or below. Thus, they are not feasible on an industrial scale.

15 Summary of the Invention

The present invention is therefore directed to provide a novel graft-polymerization method which solves the above-mentioned problems encountered in the prior art, which makes it possible to easily carry out graft polymerization on an industrial scale and which improves the grafting efficiency of an acidic vinyl monomer.

Brief Description of the Drawing

25

The sole accompanying drawing illustrates the change in grafting ratio when the graft polymerization is carried out under the polymerization conditions of the later-appearing Example 4 by adjusting in various ways the blend ratio of acrylic acid and methacrylic acid and the total monomer amount to 60 %, 100 % and 200 % owf (based on the weight of the fabric to be treated), respectively.

Description of the Preferred Embodiments

35

To accomplish the abovementioned objects, the present invention provides a method of modifying a synthetic or natural polyamide product which, in modifying a synthetic or

1 natural polyamide product by means of graft polymerization,
is characterized in that the graft polymerization is car-
ried out in an aqueous solution containing 5 to 60 mole %
of acrylic acid and 95 to 40 mole % of methacrylic acid as
5 the monomer or by adding the aqueous solution to the poly-
merization system. Furthermore, another characterizing fea-
ture of the present invention is that after the abovementioned graft polymerization is carried out, a carboxylic
acid group of the resulting polymer is converted into a
10 metal salt thereof.

As the grafting method, graft polymerization may be carried
out by activating in advance the product to be graft-poly-
merized in an aqueous solution or in a dispersion of a per-
15 oxide, such as ammonium persulfate or benzoyl peroxide, and
then heating it in an aqueous solution of the blend of the
acidic vinyl monomer defined in the present invention. Al-
ternatively, the graft polymerization may be carried out
in a redox system added with the abovementioned radical
20 initiator and a reducing agent in a weight ratio of from
1 : 1 to 1 : 20. To attain a higher grafting efficiency as
the object of the present invention, the latter provides
better results and hence is preferred.

25 When a peroxide alone is employed as the radicalpolymeriza-
tion initiator, the graft polymerization is generally car-
ried out by applying in advance the aqueous solution of the
monomer to the product (by dip-nip treatment using a mang-
le, or by spraying or coating, for example) and then heat-
30 ing the reaction system to a temperature of 90 to 100° C.,
though this will vary to some extent depending upon the
monomer composition. When the graft polymerization is car-
ried out after dipping the product, the general procedure
is to heat the reaction system to a temperature of 90 to
35 110° C. and then treat it for 50 to 120 minutes. When the
peroxide and the reducing agent are used in combination as
the radical initiator, that is, when a so-called redox ca-
talyist is employed, it is customary to leave standing the

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1 product to be graft-polymerized, which is to be heated after application thereof of the aqueous monomer solution, at 10 to 70° C. for 1 to 40 hours, or to effect steaming of the product at 90 to 110° C. for 1 to 10 minutes, though
5 the temperature and time vary with the kind and amount of the catalyst used. When the product is dipped into the aqueous monomer solution, the polymerization treatment is generally conducted at 20 to 90° C. for 5 to 120 minutes.

10 As example of the peroxide to be employed for the graft polymerization, mention can be made of those peroxides which have high oxidizing force, such as potassium persulfate, ammonium persulfate, hydrogen peroxide and benzoyl peroxide. Of these, ammonium persulfate and potassium per-
15 sulfate are suitable because they are water-soluble and have high activation property.

Examples of the reducing agent include hydrogen iodide, hydrogen sulfide, lithium aluminium hydride, sodium borohydride, sulfur dioxide, sodium sulfite, sodium sulfide,
20 sodium polysulfide, ammonium sulfide, sodium thiosulfate, sodium bisulfite, hydrosulfite, a reaction product between sodium sulfoxylate and formalin, and so forth. Among them, the reaction product between sodium sulfoxylate and formalin and hydrosulfite exhibit especially large effect. The
25 presence of the air exerts hardly any influence on the polymerization and hence purging with nitrogen or steam is not necessary. Addition of a sequestering agent such as a tripolyphosphate or ethylenediaminetetraacetate (EDTA) to
30 the aqueous solution of the graft polymerization provides a preferable result. The polymerization is preferably carried out on the acidic side below pH 7, though the pH of the aqueous solution does not impose any restriction.

35 Using a predetermined composition of acrylic acid and methacrylic acid preferably in combination with a peroxide and a reducing agent, the method of the present invention reduces the graft-polymerization time to 1/2 to 1/3 that re-

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1 quired by the conventional methods, saves energy, markedly
improves the workability and provides an unexpectedly great
improvement in the grafting efficiency. Accordingly, the
method of the present invention has great advantages for
5 the industrial application in that the monomer efficiency
is high without wasting the monomer or homopolymer, and in
that contamination due to the outflow of the monomer or ho-
mopolymer into an effluent is minimized, thereby preventing
possible environmental pollution.

10

In the modifying treatment of the polyamide product by the
graft polymerization as described above, the utilization
efficiency of the monomer is enhanced by adjusting the
blend ratio of acrylic acid and methacrylic acid in the
15 abovementioned aqueous solution to 10 to 45 mole % and 90
to 55 mole %, respectively, in comparison with cases where
acrylic acid and methacrylic acid are individually graft-
polymerized, respectively. This is illustrated in Figure 1.
If the blend ratio of acrylic acid and methacrylic acid in
20 the aqueous solution is changed to 20 to 35 mole % and 80
to 65 mole %, respectively, the utilization efficiency is
remarkably improved as shown also in Figure 1, thus making
it possible to accomplish the objects of the invention in
an extremely effective manner.

25

The term "synthetic polyamide product" used herein denotes
fibers, films and other molded articles fabricated from po-
lymers and copolymers, such as nylon 6, nylon 6.6, nylon 8,
nylon 10, nylon 12, and nylon 6.10. In particular, the me-
30 thod of the present invention is applied especially prefer-
ably to fiber products, such as filaments, yarns, knitted
fabrics, woven and non-woven fabrics, slivers, and tows.
Insofar as the objects of the present invention can be ac-
complished withouth specific problems, other polymers or
35 other fabric, such as union fabrics, mix knitted fabrics
and mixed spun fabrics, may naturally be mixed with the
abovementioned polymers or fabrics.

1 The term "natural polyamide product" used herein denotes those products which are fabricated from natural materials having amide group(s) in their molecules, such as silk, wool, and natural leathers.

5 The method of the present invention applies graft polymerization to the abovementioned synthetic or natural polyamide product and exhibits especially high grafting property to the nylon 6 or nylon 6.6 synthetic polyamide products, 10 thereby providing an extremely high grafting efficiency (monomer utilization efficiency).

If a film or a synthetic leather made of polyamide is subjected to the abovementioned graft-polymerization treatment 15 in accordance with the method of the present invention, it is possible to obtain a film or leather having such a high grafting ratio that cannot be attained by the heretofore-known graft-polymerization method. If the carboxyl group of the grafted product is substituted by an alkali metal such 20 as sodium or potassium or an ammonium group, it is possible to obtain a film or leather product having a high electric conductivity and a high moisture permeability. If the leather product thus obtained is used for shoes, it is possible to obtain a hygienic product which does not become hot 25 and stuffy. If the carboxyl group is substituted by lead or copper after the graft polymerization of acrylic acid and methacrylic acid, a product having high specific gravity can be obtained. Furthermore, the heat resistance of the product can be enhanced by substituting the carboxyl group 30 of the product by calcium, sodium or potassium. In other words, it becomes possible to furnish the product with so-called "melt resistance".

Examples 1 - 5, Comparative Examples 1 - 4

35 Filaments (150D-48f) consisting of nylon 6 were woven into a taffeta. After the taffeta was subjected to hot water washing and scouring, dipping-and-heating graft polymeriza-

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tion was carried out with each monomer ratio illustrated below to yield a grafted woven fabric having a high monomer efficiency.

5 Example

- 1 total of acrylic acid and methacrylic acid
... 60 % owf (percentage based on the weight of the fabric to be treated)

10

with a monomer ratio as follows:

acrylic acid	... 28 mole %
methacrylic acid	... 72 mole %

- 15 2 same as above with a monomer ratio as follows:

acrylic acid	... 40 mole %
methacrylic acid	... 60 mole %

- 3 same as above with a monomer ratio as follows:

20 acrylic acid	... 15 mole %
methacrylic acid	... 85 mole %

- 4 same as above with a monomer ratio as follows:

25 acrylic acid	... 50 mole %
methacrylic acid	... 50 mole %

- 5 same as above with a monomer ratio as follows:

acrylic acid	... 6 mole %
methacrylic acid	... 94 mole %

30

Each reaction was carried out using 1 % owf of ammonium persulfate and 3 % owf of a reaction product between sodium sulfoxylate and formalin as the graft-polymerization initiator and 0.3 g/l of sodium ethylenediaminetetraacetate as the sequestering agent, while the temperature was gradually elevated from 40° C. to 80° C. in the course of 30 minutes at a bath ratio of 1 : 10, and was retained at 80° C. for 60 minutes. The resulting product was then

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1 washed with water and dried and the graft ratio was determined in terms of the ratio of the increase in weight. The results are illustrated in Table 1 below.

5 For comparison, the reactions were also carried out using the same monomer in the same amount (60 % owf), the same catalyst and the same sequestering agent under the same condition as above except that each of the following monomer ratios was employed.

10

Comparative Examples

1 acrylic acid alone

15 2 methacrylic acid alone

3 acrylic acid ... 70 mole %
methacrylic acid ... 30 mole %

20 4 acrylic acid ... 3 mole %
methacrylic acid ... 97 mole %

However, the objects of the invention could not be accomplished as the monomer efficiency was extremely low.

25

Table 1

30	<u>Example</u>	<u>Monomer Blend</u> <u>(mole %)</u>		<u>Monomer</u> <u>Amount</u> <u>(% owf)</u>	<u>Grafting</u> <u>Ratio (%)</u>	<u>Monomer</u> <u>Efficiency</u> <u>(%)</u>
		<u>AA</u>	<u>MA</u>			
	1	28	72	60	45.0	75
	2	40	60	60	34.8	58
	3	15	85	60	37.2	62
35	4	50	50	60	25.8	43
	5	6	94	60	30.0	50
	Com. Ex.					
	1	100	0	60	13.2	22

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1	2	0	100	60	22.8	38
	3	70	30	60	16.8	28
	4	3	97	60	24.0	40

5 AA: acrylic acid

MA: methacrylic acid

Example 6

10 Each of the fibers illustrated below was subjected to the graft-polymerization treatment under the same conditions as in Example 1. As a result, it was found that nylon 6 and nylon 6.6 exhibited remarkable graftability and that wool and silk could also be grafted. It was also found, on
15 the other hand, that polyester and polyacrylonitrile could hardly be grafted.

Table 2

20 <u>Fiber</u>	<u>Grafting Ratio (%)</u>
Nylon 6	45
Nylon 6.6	43
Wool	13
Silk	11
25 Polyester	0,7
Polyacrylonitrile	0,5
Cotton	0,2

Example 7

30

Staple, tow and top, each of 3 deniers and consisting of nylon 6, were packed in a package dyeing machine and were graft-polymerized, respectively, using 40 % owf of a blend monomer (28 mole % acrylic acid and 72 mol % of methacry-
35 lic acid), 1 % owf of ammonium persulfate and 3 % owf of a reaction product between sodium sulfoxylate and formalin as the initiator and 0.3 g/l of disodium ethylenediamine-tetraacetate as a sequestering agent in a liquid volume

1 of a bath ratio of 1 : 5 while the temperature was gradual-
ly elevated from 40° C. to 80° C. in the course of 30 minu-
tes and was then held at 80° C. for 60 minutes. There were
thus obtained fibers having a grafting ratio of as high as
5 31 %.

Example 8

Hanks were separately prepared from twines of single fiber,
10 spun yarn consisting of nylon 6 and having fineness of 3
deniers, two-ply yarn of a 10 yarn count, filament yarn of
420 denier in total and textured yarn of 1,000 deniers in
total. Each was then graft-polymerized under the same con-
ditions as in Example 4 except that the bath ratio was
15 changed to 1 : 20. There were thus obtained grafted pro-
ducts having a grafting ratio of as high as 25 to 30 %.

Example 9

20 Non-woven fabric, taffeta and half-tricot knitted fabric,
each consisting of nylon 6, were grafted polymerized under
the same conditions as in Example 4 except that the bath
ratio was changed to 1 : 10. There were thus obtained
grafted cloths having a grafting ratio of as high as 27 to
25 32 %.

Example 10

Socks and pants-stockings each consisting of tex-
30 tured yarn of nylon 6 were graft-polymerized using a stain-
less pot under the same conditions as in Example 4 except
that the amount and blend ratio of the monomers were
changed to 10 % owf and 28 mole % acrylic acid and 72 mole
% methacrylic acid, respectively, and the bath ratio was
35 also changed to 1 : 25. There were thus obtained grafted
products having an extremely high monomer efficiency
(grafting ratio of 8.2 %). When the products were treated
with 20 % owf of an aqueous sodium carbonate solution at

-10-

1 70° C. for 30 minutes, they became products having excellent water absorbency, hygroscopicity, antistatic property and soil resistance.

5 Example 11

A stretched film consisting of nylon 6 was graft-polymerized using 50 g/l of the blend monomer of Example 4, 2 % owf of ammonium persulfate and 6 % owf of a reaction product
10 between sodium sulfoxylate and formalin as the initiator and 0,3 g/l of sodium ethylenediaminetetraacetate as the sequestering agent at a bath ratio of 1 : 200 with the other polymerization conditions such as the temperature and time being the same as those of Example 4. There was thus
15 obtained a grafted film having a high grafting ratio of 35 %. When the resulting film was treated with 50 % owf of an aqueous sodium carbonate solution, there was obtained a film having excellent antistatic property, moisture permeability and melt resistance.

20

Example 12

A leather-like cloth consisting of ultra-thin polyamide fiber having the fineness of a single fiber of 0.2 denier and
25 polyurethane was graft-polymerized in the same way as in Example 7, thus yielding a cloth having excellent moisture regaining property as well as moisture permeability.

Example 13

30

The same woven cloth as Example 1 was graft-polymerized under the same conditions as in Example 1. Thereafter, the product was treated at 80° C. for 30 minutes using a 60 % owf aqueous solution of each of the metal salts listed below to furnish products with various properties. The results are illustrated below.

1

Table 4

5	<u>Metal salt used</u>	<u>moisture regain</u>	<u>frictional static voltage</u>	<u>soil resis- tance</u>	<u>melt resis- tance</u>	<u>specific gravity</u>
	Na ₂ CO ₃	42 %	4 V	0.5 % grade	5th	1.18
	K ₂ CO ₃	43	3	0.4	5	1.17
	CaCl ₂	4.5	4,500	21.5	5	1.21
10	CuCl ₂	4.2	1,100	22.5	4	1.35
	Pb(CH ₃ COO) ₂					
	.Pb(OH) ₂	4.3	4,700	25.5	4	1.87
	-	4.4	4,600	23.5	2	1.14
	non-grafted					
15	nylon	4.3	4,700	21.7	1	1.14

1) Measurement of Hygroscopicity

One gram of the sample was placed in a weighing bottle and
 20 was dried at 105° C. for 2 hours. The weight W₀ at that
 time was measured. Next, the sample was placed in a desic-
 cator containing a saturated NaNO₂ solution and was left
 standing at 20° C. for 24 hours. The weight W at that time
 was measured. The hygroscopicity was determined in accord-
 25 ance with the following formula:

$$\text{hygroscopicity} = \frac{W - W_0}{W_0} \times 100$$

2) Measurement of frictional static voltage

30

A Sample having a length of 8 cm and a width of 5 cm was
 collected. As a cloth to be rubbed, a cotton cloth of No. 3
 shirtings was used. After the sample was left standing at
 20° C. and 30 % R.H. for one day and night, it was rotated
 35 for 60 seconds using a static tester (Kyoto University ty-
 pe, a product of Koa Shokai) to determine the static vol-
 tage (V).

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1 3) Measurement of soil release

5 cc of a soiling agent listed below, 200 cc of water and 10 pieces of steel balls were placed in a 500 cc pot. Four samples having a width of 5 cm and a length of 10 cm were placed in the pot and were treated at 60° C. for 30 minutes using a Laund-O-meter. Each of the soiled samples was washed using "Super Zabu" (detergent, a product of Kao Sekken K.K.) and a washing machine for home use, and was then dried. The L value of the sample was measured using a Hunter color difference meter and the soild release (%) was determined in accordance with the following formula:

$$\text{soil release (\%)} = \frac{\text{L value before contamination} - \text{L value after contamination}}{\text{L value before contamination}} \times 100$$

Soiling agent:

Esso automatic transmission fluid	... 300 g
coal tar	... 3 g
portland cement	... 5 g

20 Detergent:

"Super Zabu" (Kao Sekken K.K.)	... 5 g
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Generally, the soil release is at a satisfactory level if it is below 10 %.

25 4) Measurement of melt resistance

A sample was placed on a 7 mm-diameter iron rod heated to 360° C. and was brought into contact with the iron rod for 5 seconds. The extent of hole melting at that time was measured as melt resistance.

Melt resistance 5th grade: No hole was formed.

Melt resistance 4th grade: Sample was transparent, though no hole was formed.

35 Melt resistance 3rd grade: Sample was fairly transparent, though no hole was formed.

Melt resistance 2nd grade: A hole was formed to a considerable extent.

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1 Melt resistance 1st grade: Hole was formed completely.

5) Measurement of specific gravity

5 The specific gravity was measured in terms of precipitation speed when a sample was placed in aqueous sulfuric acid solutions of varying concentration as stock solutions of various specific gravities.

10 Example 14

A tricot consisting of a sheath-core fiber of 3 denier consisting of 70 wt. % of nylon 6 sheath and 30 wt. % of polyester (core) was graft-polymerized under the same
15 conditions as in Example 1, yielding a highly grafted product having high dimensional stability.

The resulting product was treated in an aqueous solution of 40 g/l of caustic soda (solid) at 98° C. for 30 minutes
20 to dissolve the polyester component by 15 % in terms of weight reduction ratio. There was thus obtained a cloth which was highly rich in drapability and which had high dimensional stability in addition to a moisture regain, antistatic property and soil release property.

25

Example 15

Mixed filament yarn consisting of 50 wt. % nylon 6 and 50 wt. % of polyester was knitted into a tricot in the
30 same way as in Example 10, which was then graft-polymerized under the same condition as in Example 11. There was thus obtained a cloth which was high in drapability, and had high dimensional stability in addition to moisture regain, antistatic property, and so forth.

35

1 Claims:

1. A method of modifying a synthetic or natural polyamide product characterized in that, in modifying a synthetic
5 or natural polyamide product by means of graft polymerization, the graft polymerization is carried out in an aqueous solution containing 5 to 60 mole % of acrylic acid and 95 to 40 mole % of methacrylic acid as the monomer or by adding said aqueous solution to the polymerization system.
10
2. The method as defined in claim 1 wherein said aqueous solution contains 10 to 45 mole % of acrylic acid and 90 to 55 mole % of methacrylic acid as the monomer.
15
3. The method as defined in claim 1 wherein said aqueous solution contains 20 to 35 mole % of acrylic acid and 80 to 65 mole % of methacrylic acid as the monomer.
- 20 4. The method as defined in claim 1 wherein the graft polymerization is carried out using a redox catalyst.
5. The method as defined in claim 1 wherein said polyamide product is a cloth, a staple, a tow or a top, a spun
25 yarn or a filament.
6. The method as defined in any of claims 4 or 5 wherein said synthetic polyamide product is nylon 6 or nylon 6.6.
30
7. The method as defined in any of claims 4 or 5 wherein said polyamide product is a fiber product.
8. The method as defined in claim 1 wherein said polyamide product is a film.
35
9. The method as defined in claim 1 wherein said polyamide product is a leather.

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- 1 10. A method of modifying a synthetic or natural polyamide
product characterized in that, in modifying a synthe-
tic or natural polyamide product by means of graft po-
lymerization, the graft polymerization is carried out
5 in an aqueous solution containing 5 to 60 mole % of
acrylic acid and 95 to 40 mole % of methacrylic acid
as the monomer or by adding said aqueous solution to
the polymerization system, and thereafter a carboxylic
acid group in the product is converted into a metal
10 salt or ammonium salt thereof.

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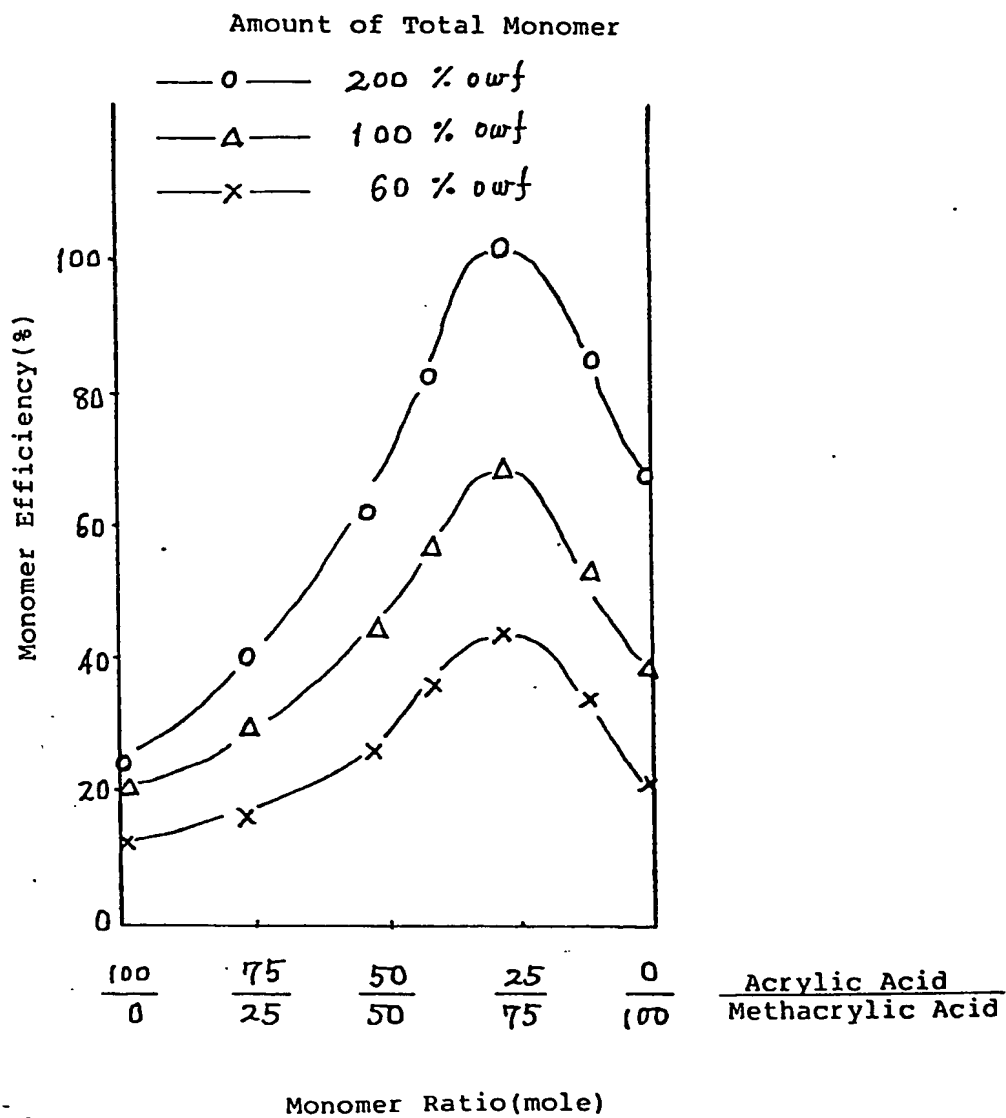
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Fig. 1



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European Patent
Office

EUROPEAN SEARCH REPORT

Application number
EP 80 10 708 1

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int. Cl.)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
	<p><u>US - A - 3 297 421</u> (K.F. TRAUMANN)</p> <p>* Claims 1,4; column 1, lines 43-45; column 2, lines 20-25 *</p> <p>--</p> <p><u>DE - A - 1 445 343</u> (DEUTSCHE AKADEMIE DER WISSENSCHAFTEN BERLIN)</p> <p>* Claim *</p> <p>--</p>	<p>1,5-8, 10</p> <p>4</p>	<p>C 08 F 283/04// (C 08 F 283/04 220/06)</p>
A	<p>CHEMICAL ABSTRACTS, vol. 77, no. 16, 16th October 1972, page 10, no. 102392m Columbus, Ohio, U.S.A. M.B. HUGLIN et al.: "Graft copolymerization of acrylic acid to nylon 6 by mutual irradiation. IV. Influence of monomer concentration"</p> <p>& EUR. POLYM. J. 1972, 8(7), 911-920</p> <p>* Abstract *</p> <p>--</p>		<p>TECHNICAL FIELDS SEARCHED (Int. Cl.)</p> <p>C 08 F 283/04</p>
X	<p><u>US - A - 3 394 985</u> (H.H. FROEHLICH)</p> <p>* Column 2, lines 48-54; column 4, lines 36-44 *</p> <p>----</p>	<p>1,4-7, 10</p>	<p>CATEGORY OF CITED DOCUMENTS</p> <p>X: particularly relevant A: technological background O: non-written disclosure P: intermediate document T: theory or principle underlying the invention E: conflicting application D: document cited in the application L: citation for other reasons</p>
<p><input checked="" type="checkbox"/> The present search report has been drawn up for all claims</p>			<p>&: member of the same patent family, corresponding document</p>
Place of search		Date of completion of the search	Examiner
The Hague		26-01-1981	MEULEMANS